Powered by
Innovation since 1886

Hydrogen Economy Vision Meeting

March 24, 2003

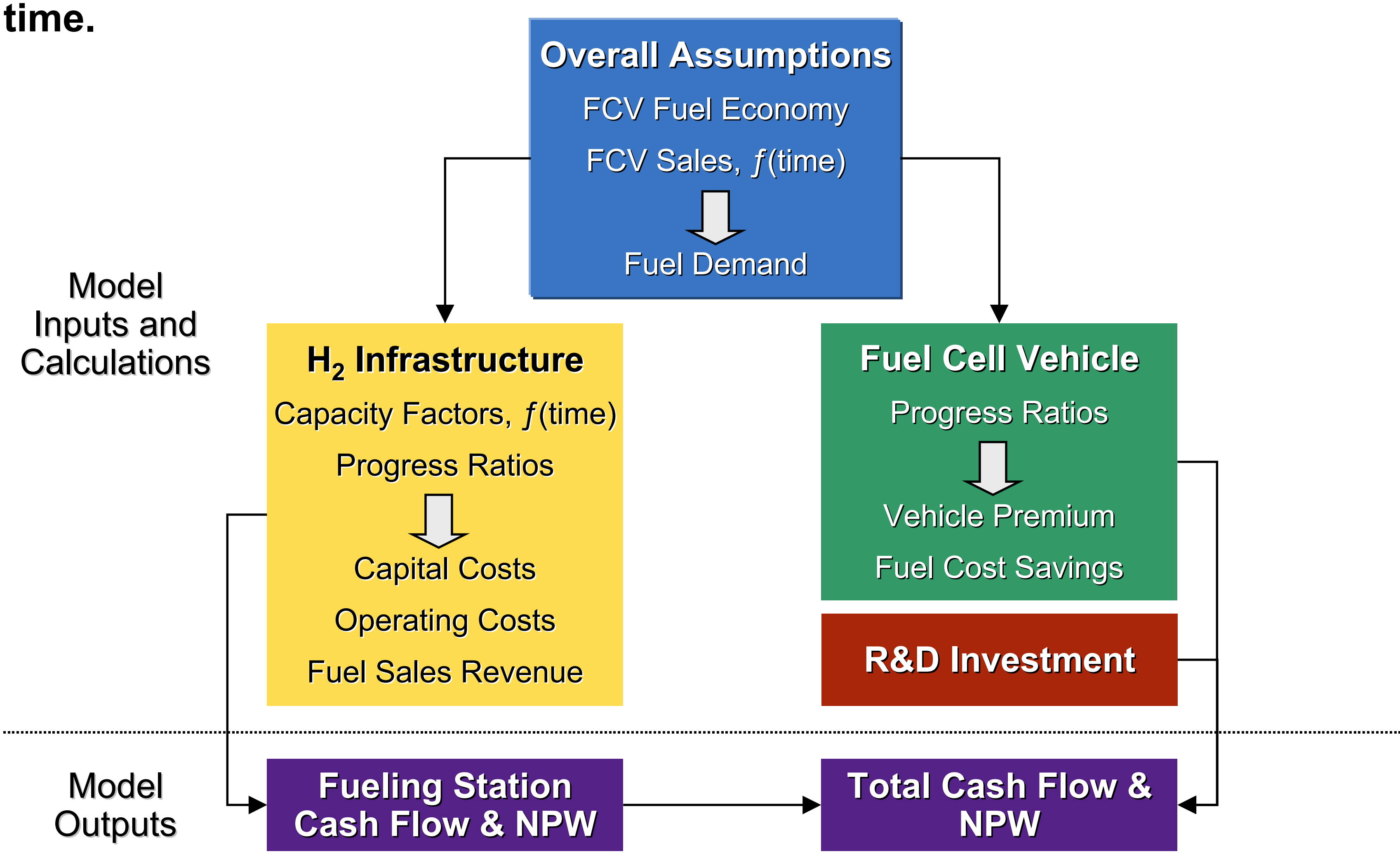
TIAX LLC
Cupertino, CA

Reference: 75111

The base case cH_2 FCV option has better overall economics than the gasoline FCV, but H_2 infrastructure risks are high.

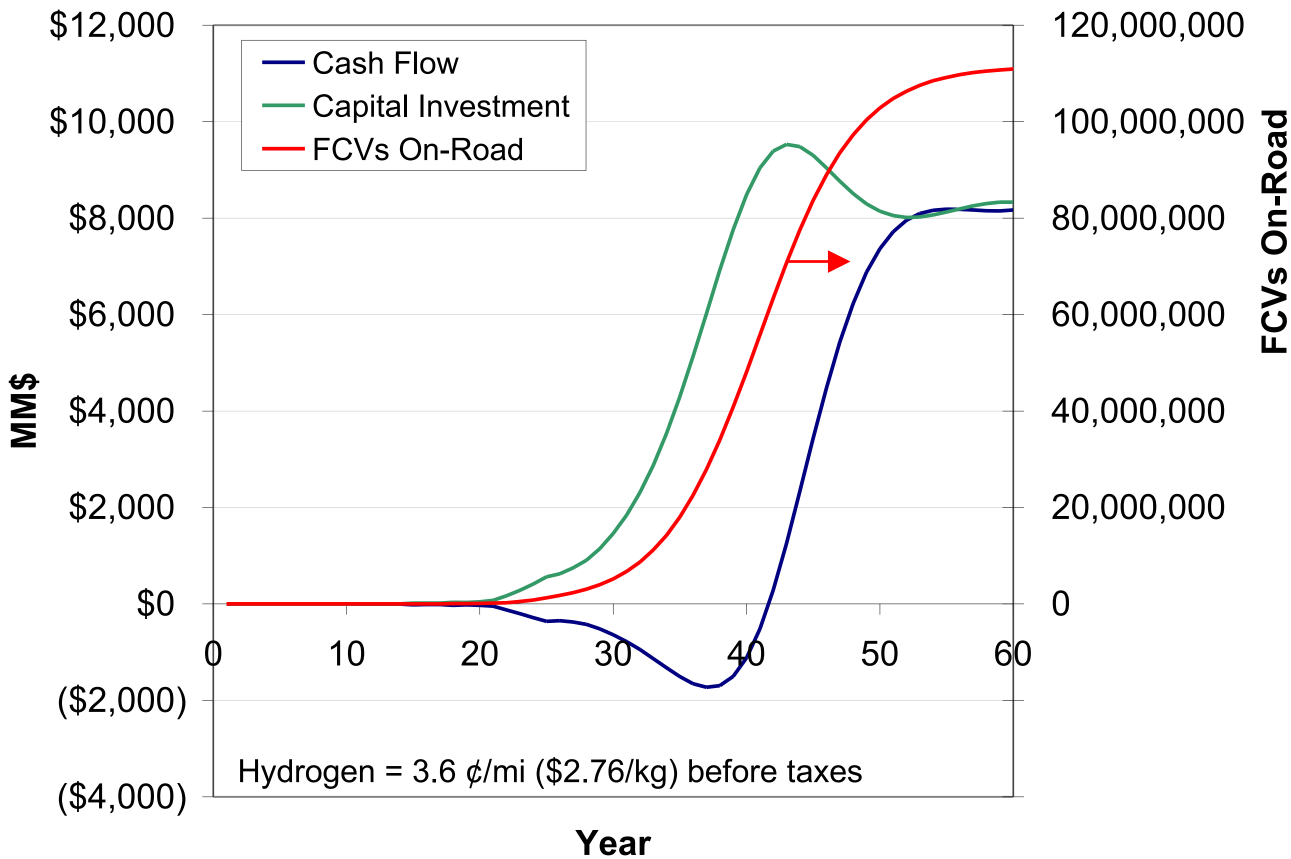
- Near-term issues are mostly technical in nature
  - Codes and standards
  - Practical refueling technology
  - Will it be cheaper to concentrate on fleet vehicles
  - Can stationary fuel cells help bring down the cost for vehicles
  - What is the source of natural gas for reformed hydrogen
- Long-term issues are about money and environmental impacts
  - What is the "end game" (about year 2050)
  - What are the "transition" strategies
  - What are the "delivery" options from centralized facilities
  - What are the sources of renewable hydrogen
  - Who will invest in hydrogen infrastructure when the risks are high

A net present worth (NPW) model has been developed to track cash flow and NPW results based on vehicle and H_2 infrastructure investments over time.



Assuming a H_2 fuel price equivalent to conventional vehicles on a per mile basis, H_2 station cash flow could be positive $8 billion/yr in 50 years *.

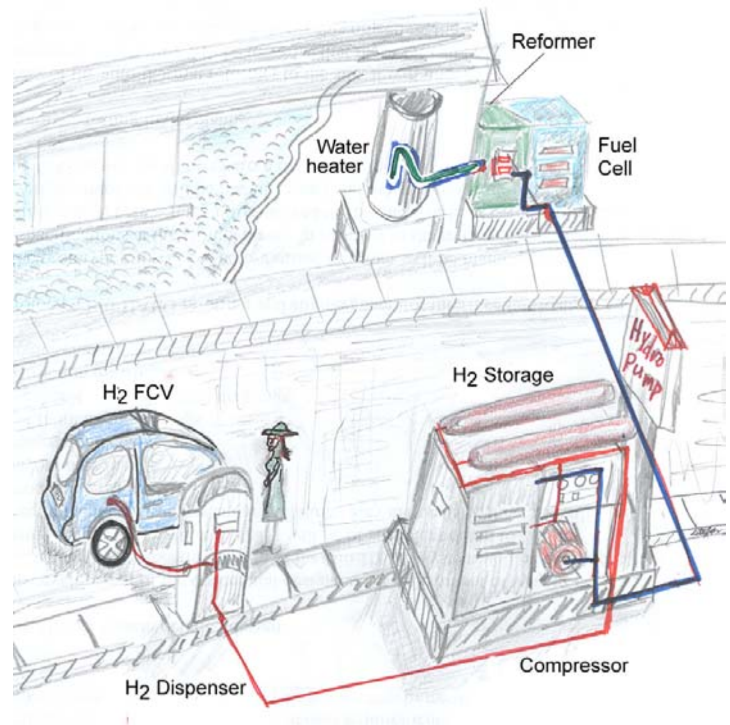
H_2 Fueling Station Cash Flow and Capital Investment -- EXAMPLE



* Assumes direct hydrogen FCV introduction starts in 2003 (year 1) and proceeds according to an S-curve fit to OTT's 3% Case from 2030 to 2050. Actual FCVs on the road are 33% of light duty vehicles by 2050 (Year 47).

An energy station would provide fuel to fuel cell vehicles, as well as power, heat, and cooling to buildings to optimize energy use and minimize cost.

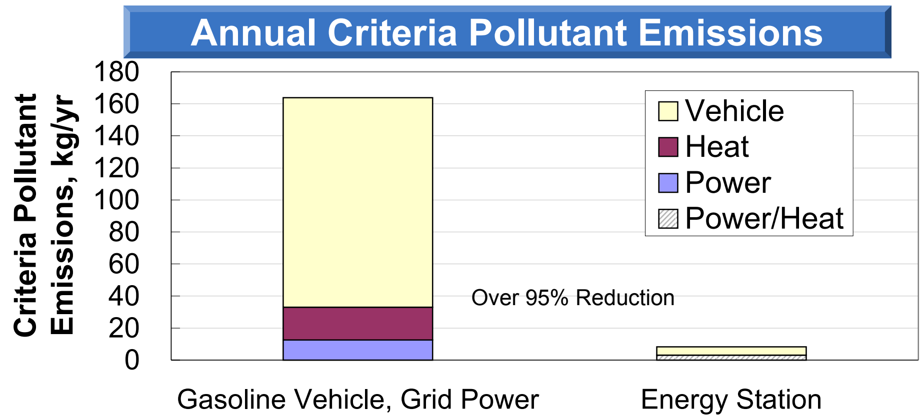
- Central reformer and hydrogen storage in fueling station
- Hydrogen fuel cell vehicles such as cars, buses, and delivery vehicles
- Distributed power generation using PEM fuel cells
- Initially sited in location where fleets fuel
- Success depends on:
  - Efficient and low-cost compressor arrangement
  - Low-cost reformer
  - High-yield purification
  - High value distributed generation operating strategies



With an energy station, optimal use of natural resources could be combined with zero emissions and extremely high reliability.

- Flexible energy sources
- Over 90% reduction of criteria pollutant emissions
- Enhances grid reliability through energy storage and fuel cells with few moving parts
- Reduced greenhouse gas emissions
- Managed technical risk through use of hydrogen fuel cells rather than conventional stationary fuel cell systems
- Facilitates implementation of fueling infrastructure
- Low cost through shared components

Individual components do not provide same benefit



Note: criteria pollutants include NOx, CO, and NMOG